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## CONNECTION DEVICE BETWEEN MEMBERS OF A MACHINE

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DESCRIPTION

The present invention refers to a connection device between members of a machine.

In particular, hereafter reference shall be made to connection devices of the type usually used for example in machine tools for the connection of a rotary head or else a rotary table. In other examples, such devices are used to displace or rotate a member of a machine by a certain angle with respect to another, for example the device can be used in marble machines, machines for joinery, manipulators, etc.

Currently there are two types of chip machines: continuous treatment machines and discontinuous treatment machines.

The first (i.e. continuous treatment machines) are equipped with a treatment head or piece-carrying table the position and mutual orientation of which can be modified continuously through stepper motors controlled by the electronics of the machine.

Machines of this type allow even very complex treatments to be carried out but, however they have drawbacks which in practice limit its use above all in very heavy duty treatments.

Indeed, continuous treatment machines, during operation, generally have high vibrations, low chip removal and, therefore, long treatment times.

Moreover, continuous treatment machines are usually very

expensive and are not very strong and a limited resolution (usually the maximum resolution that can be obtained with a continuous treatment machine is equal to  $0.001^\circ$ ).

Discontinuous treatment chip machines, on the other hand, are realised by using Hirth connection devices.

Hirth devices are realised through two identical discs, equipped with front teeth, which are connected together engaging the respective teeth between them.

The discs can be rotated with respect to each other before connection so as to be positioned as required by the treatment being carried out and, therefore, so as to position as desired the mechanical member connected to them, usually consisting of the piece-carrying table or else the treatment head.

The devices of the type indicated are highly used in practice since they allow the machine members to be positioned as required for the particular treatment being carried out and the connection between the discs is strong and precise enough to be used even for calibrated positioning.

Machines which use Hirth devices are usually strong, they are not affected by vibrations and they allow large quantities of chips to be removed at each run. However, they are not very flexible and their use becomes all the more difficult, up to the point of becoming practically impossible, when very high resolutions are desired.

Indeed, the resolution which can be obtained with

conventional devices of this type becomes greater as the number of teeth possessed by the discs (of the same type) becomes greater.

This is due to the fact that the discs have the same number of teeth and, therefore, the greater the number of teeth, the greater the number of positions in which a disc of  $360^\circ$  is divided (the positions are defined, for example, by the hollows between two teeth of a disc in which the teeth of the other disc insert).

This necessarily implies that to obtain greater resolution and, therefore, to divide the  $360^\circ$  angle into many positions it is necessary to increase the number of teeth.

Moreover, it must be considered that the teeth must transmit a torque and, therefore, their thickness cannot be too thin otherwise it would be too weak and there could be the risk, if subjected to too high forces, of them breaking.

Of course, these two drawbacks combined with each other mean that in practice as the required resolution increases the diameter needed for the discs increases and, therefore, the bulk, the weight, etc. increases.

The technical task proposed of the present invention is, therefore, that of realising a connection device between members of a machine which allows the aforementioned technical drawbacks of the prior art to be eliminated.

In this technical task, a purpose of the invention is that of realising a connection device between members of a machine which is flexible and capable of working with very

high resolution.

Another purpose of the invention is that of realising a device which is very strong. In particular, the teeth which allow the mutual connection of the discs are very strong and must not preferably be made very thin to increase the resolution of the device.

The last but not least purpose of the invention is that of realising a device which is very light and not very bulky, in particular compared with an analogous conventional device.

The technical task, as well as these and other purposes, according to the present invention are accomplished by realising a connection device between members of a machine comprising at least one first and one second coupling suitable for being connected together to orientate said members of said machine in work position, characterised in that said first coupling comprises at least one first and one second toothed elements mutually mobile between an initial reference configuration and a work configuration corresponding to a predetermined orientation of said members of said machine, said second coupling comprising at least two toothed elements fixed together with said initial configuration and mutual displacement means of said second coupling with respect to said first coupling suitable for taking said second coupling into a connection position with said first coupling once said work condition of said first coupling has been reached in correspondence with a small relative displacement between said first and second toothed

elements of said first coupling equal to the difference between the sum of the pitch of two or more teeth of said first toothed element of said first coupling and the sum of the pitch of two or more teeth of said second toothed element of said first coupling.

Other characteristics of the present invention are, moreover, defined in the other claims.

Further characteristics and advantages of the invention shall become clear from the description of a preferred but not exclusive embodiment of the connection device between members of a machine according to the finding, where the device is illustrated for indicating and not limiting purposes in the attached drawings, wherein:

- figure 1 shows an exploded perspective view of the device according to the finding;
- figure 2 shows a perspective view of the elements of the device according to the finding; and
- figure 3 shows a side top view of two couplings coupled together.

With reference to the quoted figures, a connection device between members of a machine is shown, wholly indicated with reference numeral 1.

The device 1 comprises a first and a second coupling 2, 3 suitable for being connected together to orientate the members of the machine in work position.

In particular, the first coupling 2 comprises two toothed elements 4, 5 mutually mobile between an initial reference

configuration and a work configuration corresponding to a predetermined orientation of said members of said machine.

Such toothed elements 4 and 5 are connected to the members of the machine which must be positioned with respect to each other.

Figure 1 represents an example of a coupling in which the reference is defined by the teeth 6 and 7 respectively of the elements 4 and 5 which are aligned.

The second coupling comprises two mutually fixed toothed elements 8, 9 having the initial configuration (defined by the teeth 10 and 11 aligned with each other and aligned with the teeth 6 and 7 so as to allow the mutual connection of the two couplings).

The device also comprises displacement means 12 of the second coupling 3 with respect to the first coupling 2, suitable for taking the second coupling into a connection position with the first coupling.

The toothed elements are constructively simple and are very practical to use. However, in different embodiments the couplings have connection means different from toothings such as, for example, cylindrical pins inserted in holes, etc.

Suitably, the displacement means 12 are suitable for displacing or rotating the second coupling 3 with respect to the first coupling 2 by an amount proportional to the relative displacement of the two elements 4, 5 of the first coupling 2.

As shown in the attached figures, preferably the mutually

mobile toothed elements 4, 5 of the first coupling 2 have an annular configuration and are concentric and, correspondingly, the mutually fixed toothed elements 8, 9 of the second coupling 3 also have an annular configuration and are concentric.

Moreover, the mutually mobile toothed elements 4, 5 of the first coupling 2 have different numbers of teeth and, at the same time, the mutually fixed toothed elements 8, 9 of the second coupling 3 also have different numbers of teeth.

Advantageously, the inner mobile toothed elements 5 and the inner fixed toothed elements 9 have fewer teeth than corresponding outer mobile toothed elements 4 and outer fixed toothed elements 8.

In this way, the teeth of the inner toothed elements have a large thickness (in any case greater than the case in which the teeth of the inner elements are greater in number with respect to the teeth of the outer elements) and are, therefore, very strong.

In a different example the inner mobile toothed elements 5 and the inner fixed toothed elements 9 have a greater number of teeth than corresponding outer mobile toothed elements 4 and outer fixed toothed elements 8.

Moreover, the inner mobile toothed elements 5 and the inner fixed toothed elements 9 have the same number of teeth and, in the same way, the outer mobile toothed elements 4 and the outer fixed toothed elements 8 have the same number of teeth.

In a preferred embodiment, the difference between the number of teeth of the outer mobile toothed elements 4 and of the inner mobile toothed elements 5 is greater than one and, moreover, the difference between the number of teeth of the outer fixed toothed elements 8 and of the inner fixed toothed elements 9 is greater than one.

For example, by realising inner mobile and fixed elements equipped with 32 teeth and outer mobile and fixed toothed elements with 45 teeth, a resolution of  $0.25^\circ$  can be obtained.

Thus, by rotating the inner toothed element with respect to the outer toothed element of the first coupling in a certain direction by an amount equal to such a minimum resolution, the alignment between the seventh tooth of the outer toothed element and the fifth tooth of the inner toothed element of such a first coupling is recreated, then the second coupling is rotated by  $56^\circ$  in the opposite direction to the direction of rotation of the inner toothed element of the first coupling so as to achieve the engagement with the first coupling.

Advantageously, the machine is a chip machine and the device connects a piece-carrying table and/or a treatment head and/or a piece-carrying chuck and/or a divider to a structure of the machine.

In other examples the machine is a divider or else a machine for treating wood or marble, a grinder, a welder, a measuring instrument, machines which operate in gradual



measurement, textile machines, etc. In practice, the device according to the present finding can advantageously be used in whatever mechanism, even manual, which needs to make gradual divisions.

The operation of the connection device between members of a machine according to the invention is clear from that which has been described and illustrated and, in particular, is substantially the following.

Initially, the two couplings are interfaced and the reference elements are aligned with each other.

In practice, therefore, the two couplings are interfaced and the teeth 6, 7 of the first coupling are aligned with the hollow 13 defined by the teeth 10, 11 of the second coupling 3.

In this way the two couplings 2, 3 can be connected together by making them translate towards each other along the axis 14.

When one wishes to change the relative orientation of piece-carrying table or treatment head, the inner mobile element 5 is rotated, with respect to the outer mobile element 4, by an amount which is sufficient to position the piece-carrying table or treatment head as desired.

Then, to connect the two couplings, the second coupling 3 is rotated by a predetermined amount proportional to the rotation applied to the inner mobile element 5.

For example, the small displacement which it is possible to realise with the device represented in the attached

figures is equal to  $2.7272^\circ$ , which is realised by aligning the teeth A and B after the teeth 7, 6 and by rotating the second coupling 3 by  $30^\circ$  in the opposite direction to align it with the first coupling and to allow the connection.

In this way, the reference of the second coupling 3 (i.e. the hollow 13 defined by the aligned teeth 10 and 11 which are fixed with respect to each other) is brought back aligned with the new reference of the first coupling (i.e. with the aligned teeth A and B), making the connection between the two couplings 2, 3 possible.

Hereafter, some examples of connection devices of the type indicated shall be described and they shall be compared with equivalent conventional devices.

In a first example, we want to realise a device that is able to obtain a resolution of 1 degree.

Thus, considering an outer toothed element with 40 teeth with an angular pitch of  $9^\circ$  and an inner toothed element with 9 teeth with an angular pitch of  $40^\circ$ , and rotating the inner toothed element with respect to the outer toothed element of the first coupling in a certain direction of rotation by an amount equal to such a minimum resolution, the alignment between the ninth tooth of the outer toothed element and the second tooth of the inner toothed element of such a first coupling is recreated, then the second coupling is rotated by  $81^\circ$  in the same direction as the direction of rotation of the inner toothed element of the first coupling so as to achieve the engagement with the first coupling.

It must be noted that the fitting between the first and second coupling is made possible by the fact that the work configuration thus obtained by the first coupling recreates the initial reference configuration of the first coupling wherein, however, in place of the teeth of the initial reference configuration, the ninth tooth of the outer toothed element and the second tooth of the inner toothed element of the first coupling are aligned.

As is clear, the minimum resolution which can be obtained is equal to the difference between the sum of the pitch of the ninth tooth of the outer toothed element and the sum of the pitch of two teeth of the inner toothed element.

Using a conventional device toothed elements would have to be realised having an outer diameter equal to about 500 millimetres (due to the smallest possible size of the teeth for reasons strength and the number of teeth necessary).

Using the device according to the finding, on the other hand, toothed elements having an outer diameter of about 70 millimetres are sufficient.

In a second example we want to realise a device that is able to obtain a resolution of 0.5 degrees.

Using a conventional device toothed elements would have to be realised having an outer diameter equal to about 600 millimetres, whereas using the device according to the finding toothed elements having an outer diameter of about 70 millimetres are sufficient.

In a third example we want to realise a device that is

able to obtain a resolution of  $0.25^\circ$ .

Using a conventional device toothed elements would have to be realised having an outer diameter equal to about 1000 millimetres, whereas using the device according to the finding toothed elements having an outer diameter of about 100 millimetres are sufficient.

In a fourth example we want to realise a device that is able to obtain a resolution of  $0.1^\circ$ .

Using a conventional device toothed elements would have to be realised having an outer diameter equal to about 3000 millimetres, whereas using the device according to the finding toothed elements having an outer diameter of about 125 millimetres are sufficient.

In a fifth example we want to realise a device that is able to obtain a resolution of  $0.05^\circ$ .

Using a conventional device toothed elements would have to be realised having an outer diameter equal to about 5500 millimetres, whereas using the device according to the finding toothed elements having an outer diameter of about 180 millimetres are sufficient.

In a sixth example we want to realise a device that is able to obtain a resolution of  $0.01^\circ$ .

Using a conventional device toothed elements would have to be realised having an outer diameter equal to about 25,000 millimetres, whereas using the device according to the finding toothed elements having an outer diameter of about 240 millimetres are sufficient.

In a seventh example we want to realise a device that is able to obtain a resolution of  $0.005^\circ$ .

Using a conventional device toothed elements would have to be realised having an outer diameter equal to about 50,000 millimetres, whereas using the device according to the finding toothed elements having an outer diameter of about 500 millimetres are sufficient.

In an eighth example we want to realise a device that is able to obtain a resolution of  $0.001^\circ$ .

Thus, considering an outer toothed element with 625 teeth and an inner toothed element with 9 teeth, and rotating the inner toothed element with respect to the outer toothed element of the first coupling in a certain direction of rotation by an amount equal to such a minimum resolution, the alignment between the fifty-first tooth of the outer toothed element and the forty-seventh tooth of the inner toothed element of such a first coupling is recreated, then the second coupling is rotated by  $29,376^\circ$  in the same direction as the direction of rotation of the inner toothed element of the first coupling so as to achieve the engagement with the first coupling.

Using a conventional device toothed elements would have to be realised having an outer diameter equal to about 250,000 millimetres, whereas using the device according to the finding toothed elements having an outer diameter of about 550 millimetres are sufficient.

In a ninth example we want to realise a device that is

able to obtain a resolution of  $0.0005^\circ$ .

Using a conventional device toothed elements would have to be realised having an outer diameter equal to about 500,000 millimetres, whereas using the device according to the finding toothed elements having an outer diameter of about 1000 millimetres are sufficient.

In a tenth example we want to realise a device that is able to obtain a resolution of  $0.0001^\circ$ .

Thus, considering an outer toothed element with 3125 teeth and an inner toothed element with 1152 teeth, and rotating the inner toothed element with respect to the outer toothed element of the first coupling in a certain direction of rotation by an amount equal to such a minimum resolution, the alignment between the  $963^{\text{rd}}$  tooth of the outer toothed element and the  $355^{\text{th}}$  tooth of the inner toothed element of such a first coupling is recreated, then the second coupling is rotated by  $1,109,376^\circ$  in the same direction as the direction of rotation of the inner toothed element of the first coupling so as to achieve the engagement with the first coupling.

Using a conventional device toothed elements would have to be realised having an outer diameter equal to about 2,500,000 millimetres, whereas using the device according to the finding toothed elements having an outer diameter of about 2400 millimetres are sufficient.

The present finding also refers to a machine tool equipped with the device described previously.

The machine tool comprises a connection device between its members which comprises a first and a second coupling suitable for being connected with each other to mutually orientate the members in work position.

The first coupling comprises at least two toothed elements mutually mobile between an initial reference configuration and a work configuration corresponding to a predetermined orientation of the members of the machine tool.

The second coupling comprises at least two mutually fixed toothed elements having the initial configuration and displacement means of the second coupling with respect to the first coupling suitable for taking the second coupling into a connection position with the first coupling.

In practice, it has been noted how the connection device between members of a machine according to the invention is particularly advantageous because it is very precise and strong, it allows complete reproducibility, it has substantial resolution and, at the same time, it has low bulk and weight.

The connection device between members of a machine thus conceived is susceptible to numerous modifications and variants, all covered by the inventive concept. Moreover, all of the details can be replaced with others which are technically equivalent.

In practice, the materials used, as well as the sizes, can be whatever, according to the requirements and the state of the art.